Effect of electric and magnetic fields on operation of insulin pumps under 400 kV power lines

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Abstract – The aim was to study the operation of insulin pumps under a 400 kV transmission line (two test places) and possible disturbances that the lines could have caused. Three different insulin pumps were attached one at a time to the subject’s clothes. The diabetes nurse started the pumps before the tests to ensure the correct settings were being utilized. After walking under the power lines when meters were running, she tested if the meters had operated properly. At the first test site (A), the electric field was 5.0–5.1 kV/m and the magnetic field 8.6–10.9 μT, and in the second test place (B), the fields were 7.7–8.5 kV/m and 5.7–9.2 μT. The pumps worked perfectly: no disruption was detected in the flow, display or menu movement, and the events were registered correctly. Only the remote control, which worked well before and after the test, could not reliably receive additional doses. However, the functions of the insulin pump are not dependent on the functionality of the remote control device, so the study suggests that insulin pump users can move safely under the power lines.

Keywords: electromagnetic field / exposure / personnel / radiation / non-ionizing

1 Introduction

The use of insulin pumps has increased among children and adults with type 1 diabetes (Sherr et al., 2016; Karges et al., 2017), e.g., from 0.6 to 1.3% in 1995 to 44 to 47% between 2012 and 2016 (Karges et al., 2014; Bohn et al., 2016; Szypowska et al., 2016). However, according to Heinemann et al. (2015), with modern insulin pumps, errors of insulin infusion can occur due to pump failure, insulin infusion set (IIS) blockage, infusion site problems, insulin stability issues, user error, or a combination of factors (Heinemann et al., 2015).

Electromagnetic field exposure guidelines for the general public describe that the general exposure limits may not sufficiently protect users of medical implants (European Recommendation, 1999; ICNIRP, 2010). Zradziński et al. (2018a) studied the effects of exposure to a low or intermediate frequency electromagnetic field (LIF-EMF), characterized by the electric field induced in the body, in order to evaluate how the type of insulin needle and the way it is injected influences the exposed user of a wearable insulin pump. They used numerical models of exposure scenarios. Based on the calculations they concluded that, when steel insulin needles were used, the assessment of users’ EMF exposure should be carried out using magnetic field limits at least 5-times lower than given in the general international requirements (Zradziński et al., 2018a).

The use of portable drug pumps, such as insulin pumps has increased, and their functions have become more diverse and sophisticated. Therefore, it is important to know more about their potential disruption, for example, when moving in the vicinity of power lines. The aim of the study is to investigate the operation and failures of insulin pumps under a 400 kV transmission line.

2 Measurement situations and methods

Insulin pumps were examined under the guidance of the diabetes nurse. Three different insulin pumps were attached one at a time to the subject’s clothes. The diabetes nurse started the pumps before the tests to ensure the pumps would operate under the correct settings. After the test subject had walked under the power line, the nurse tested the operation of the equipment. The following devices were included in the study: 1) Paradigm Veo System (Medtronic); 2) ACCU-CHEK Spirit Combo including the remote control unit (Roche); and 3) Animas 2020 (Pharmanova Oy). The remote control of the ACCU-CHEK pump was also tested again. Two measuring
points were used under the power line. Figure 1 shows the measurement places near power lines (Figs. 1a and 1b) and also the tested devices (Figs. 1c–1e).

The base dose for the pumps was 1.3 U/h (units per hour). In both places, both the fast 4.0 U and the extended (30 min) 4.0 U additional doses were taken. The remote control device of the ACCU-CHEK pump also received a rapid additional dose of 4.0 U. The remote control device was subsequently tested again with an additional dose of 4.0 U. Figure 2 shows the test protocols.

We performed the electric field measurements with a commercial EFA-300 meter, using the three-axis E-Field Probe 2245-302 attachment (accuracy: 3%, rms) calibrated by the manufacturer (Narda Safety Test Solutions GmbH, Pfullingen, Germany). The frequency range was 5–30 kHz, the measurement height was 1.7 m, and the magnetic fields were measured with a Narda ELT-400 meter (L-3Communications, Narda Safety Test Solutions, Hauppauge, NY, USA) (accuracy ± 4% RMS), which has a frequency range of 1 Hz–400 kHz.

Fig. 1. Pictures under the power lines (a + b), and instrument set-up (c–e).
# Results and discussion

During the tests, the electric field measured at the power line at site A was 5.0–5.1 kV/m, with the magnetic field in the range of 8.6–10.9 μT; and at site B, the fields were 7.7–8.5 kV/m and 5.7–9.2 μT. The measurement height was 1.7 m. The temperature was between 21.6–30.0 °C and the humidity varied from 44 to 63% (Tab. 1).

The pumps worked properly: no disruption was detected in the flow, display, or menu movement and the events were registered correctly. Only the remote control, which worked well before and after the test, could not reliably receive additional doses under the power lines. However, the functions of the insulin pump are not dependent on the functionality of the remote control device; thus, the study suggests that insulin pump users can move safely under power lines.

## Acknowledgements

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## References


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## Table 1. Electric and magnetic fields at measurement places.

<table>
<thead>
<tr>
<th>No.</th>
<th>Place</th>
<th>Magnetic field (μT)</th>
<th>Electric field (kV/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>9.0–10.0</td>
<td>5.1</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
<td>8.6–9.0</td>
<td>5.1</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>10.4–10.9</td>
<td>5.1</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
<td>9.7–10.2</td>
<td>5.0</td>
</tr>
<tr>
<td>5</td>
<td>B</td>
<td>5.7–6.1</td>
<td>8.1</td>
</tr>
<tr>
<td>6</td>
<td>B</td>
<td>6.5–7.4</td>
<td>7.9–8.5</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>8.4–8.7</td>
<td>7.7–7.8</td>
</tr>
<tr>
<td>8</td>
<td>B</td>
<td>8.6–9.2</td>
<td>7.8</td>
</tr>
</tbody>
</table>

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## 3 Results and discussion

We searched in PubMed using (1) (insulin pump) AND (power line); (2) (insulin pump) AND (electric field); (3) (insulin pump) AND (magnetic field). We did not find any experiments under power lines. Zradziński et al. (2018b), evaluated of the safety of users of active implantable medical devices (AIMD) in the working environment in terms of exposure to electromagnetic fields. However, they did not report results of insulin pumps under power lines.

## 4 Conclusion

The functions of the insulin pump are not dependent on the functionality of the remote control device; hence, the study suggests that insulin pump users can move safely under power lines.

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**Fig. 2.** Dosage and measurement protocols.

**Table 1.** Electric and magnetic fields at measurement places.


